

CLAIMS

We claim:

- [c1] 1. A computer system comprising:
a chassis;
a first computer module compartment positioned in the chassis and in an air flow path;
a second computer module compartment positioned in the chassis and in the air flow path; and
a heat exchanger positioned in the chassis and in the air flow path.
- [c2] 2. The computer system of claim 1 wherein the heat exchanger is positioned at least partially downstream of the first computer module compartment and at least partially upstream of the second computer module compartment.
- [c3] 3. The computer system of claim 1 wherein the heat exchanger includes at least one internal fluid passage configured to carry a working fluid.
- [c4] 4. The computer system of claim 1 wherein the heat exchanger includes at least one internal fluid passage configured to carry a working fluid having a boiling point in the heat exchanger between about 45°F and about 75°F.
- [c5] 5. The computer system of claim 1 wherein the heat exchanger includes at least one opening through which air can pass from at least proximate the first computer module compartment to at least proximate the second computer module compartment.
- [c6] 6. The computer system of claim 1 wherein the heat exchanger is positioned at least partially between the first and second computer module compartments in the chassis.

- [c7] 7. The computer system of claim 1 wherein the heat exchanger is a first heat exchanger, and wherein the computer system further comprises:
 a third computer module compartment positioned in the chassis and in the air flow path; and
 a second heat exchanger positioned in the chassis and in the air flow path, wherein the second heat exchanger is positioned at least partially downstream of the second computer module compartment and at least partially upstream of the third computer module compartment.
- [c8] 8. The computer system of claim 1 wherein the heat exchanger is a first heat exchanger, and wherein the computer system further comprises:
 a third computer module compartment positioned in the chassis and in the air flow path; and
 a second heat exchanger positioned in the chassis and in the air flow path, wherein the second heat exchanger is positioned at least partially downstream of the second computer module compartment and at least partially upstream of the third computer module compartment, wherein the first, second, and third computer module compartments, and the first and second heat exchangers, are arranged vertically in the chassis.
- [c9] 9. The computer system of claim 1 wherein the first computer module compartment, the second computer module compartment, and the heat exchanger are arranged vertically in the chassis.
- [c10] 10. The computer system of claim 1 wherein the first computer module compartment is configured to hold at least a first computer module oriented edgewise with respect to the air flow path.

- [c11] 11. The computer system of claim 1 wherein the first computer module compartment is configured to hold a plurality of computer modules oriented edgewise with respect to the air flow path.
- [c12] 12. The computer system of claim 1 wherein the first computer module compartment is configured to hold at least a first computer module oriented edgewise with respect to the air flow path toward a first side of the heat exchanger, and wherein the second computer module compartment is configured to hold at least a second computer module oriented edgewise with respect to the air flow path toward a second side of the heat exchanger opposite to the first side of the heat exchanger.
- [c13] 13. The computer system of claim 1, further comprising:
 a first computer module carried by the first computer module compartment,
 wherein the first computer module includes at least a first computer processor; and
 a second computer module carried by the second computer module compartment, wherein the second computer module includes at least a second computer processor.
- [c14] 14. The computer system of claim 1, further comprising an air mover configured to move air past the heat exchanger along the air flow path in the chassis.
- [c15] 15. The computer system of claim 1, further comprising an air mover carried by the chassis and configured to move air past the heat exchanger along the air flow path in the chassis.
- [c16] 16. A computer system comprising:
 a chassis;

a first computer module compartment positioned in the chassis and in an air flow path; and

a heat exchanger positioned at least proximate to the first computer module compartment and in the air flow path, the heat exchanger including at least one internal fluid passage configured to carry a working fluid having a boiling point in the heat exchanger between about 45°F and about 75°F.

[c17] 17. The computer system of claim 16 wherein the first computer module compartment is configured to hold a plurality of computer modules oriented edgewise with respect to the air flow path.

[c18] 18. The computer system of claim 16 wherein the first computer module compartment is position at least proximate to a first side of the heat exchanger, and wherein the chassis further includes a second computer module compartment positioned in the air flow path in the chassis at least proximate to a second side of the heat exchanger opposite to the first side of the heat exchanger.

[c19] 19. The computer system of claim 16 wherein the heat exchanger is a first heat exchanger, and wherein the computer system further comprises:

a third computer module compartment positioned in the air flow path in the chassis; and

a second heat exchanger positioned at least partially between the second and third computer module compartments in the air flow path in the chassis, the second heat exchanger including at least one internal fluid passage configured to carry a working fluid having a boiling point in the second heat exchanger between about 45°F and about 75°F.

- [c20] 20. The computer system of claim 16, further comprising an air mover configured to move air through at least one opening in the heat exchanger along the air flow path in the chassis.
- [c21] 21. The computer system of claim 16, further comprising the working fluid, wherein the working fluid is carried by the internal fluid passage of the heat exchanger.
- [c22] 22. The computer system of claim 16, further comprising the working fluid, wherein the working fluid is carried by the internal fluid passage of the heat exchanger, and wherein a first portion of the working fluid is in a liquid state and a second portion of the working fluid is in a gaseous state in the heat exchanger.
- [c23] 23. The computer system of claim 16, further comprising the working fluid, wherein the working fluid is a refrigerant.
- [c24] 24. The computer system of claim 16, further comprising the working fluid, wherein the working fluid is a refrigerant having a boiling point in the heat exchanger between about 50°F and about 65°F.
- [c25] 25. The computer system of claim 16 wherein the heat exchanger is positioned upstream of the first computer module compartment in the chassis.
- [c26] 26. A computer system comprising:
a chassis;
a first computer module compartment positioned in the chassis and in an air flow path;
a first heat exchanger positioned in the chassis and in the air flow path, wherein the first heat exchanger includes at least one internal fluid passage configured to carry a working fluid that absorbs heat from air flowing in the air flow path; and

a second heat exchanger in fluid communication with the first heat exchanger, wherein the second heat exchanger is configured to cool the working fluid carried by the first heat exchanger.

[c27] 27. The computer system of claim 26, further comprising the working fluid, wherein the working fluid has a boiling point in the first heat exchanger between about 45°F and about 75°F.

[c28] 28. The computer system of claim 26, further comprising a plurality of computer modules held in the first computer module compartment.

[c29] 29. The computer system of claim 26, further comprising a second computer module compartment positioned in the chassis and in the air flow path, wherein the first heat exchanger is positioned at least partially between the first and second computer module compartments.

[c30] 30. The computer system of claim 26 wherein the second heat exchanger is spaced apart from the chassis.

[c31] 31. The computer system of claim 26, further comprising a controller operably coupled to the second heat exchanger to maintain the working fluid in phase transition within the first heat exchanger.

[c32] 32. The computer system of claim 26 wherein the first computer module compartment is configured to hold a plurality of computer modules oriented edgewise with respect to the air flow path.

[c33] 33. A computer system comprising:
a chassis;

an air mover positioned in flow communication with the chassis, wherein the air mover is configured to move air along a flow path through at least a portion of the chassis;

a first computer module compartment positioned in the air flow path in the chassis;

a first plurality of computer modules held in the first computer module compartment at least partially in the air flow path;

a second computer module compartment positioned in the air flow path in the chassis and spaced apart from the first computer module compartment;

a second plurality of computer modules held in the second computer module compartment at least partially in the air flow path; and

a heat exchanger positioned in the air flow path in the chassis, wherein the heat exchanger is positioned at least partially downstream of the first computer module compartment and at least partially upstream of the second computer module compartment, and wherein the heat exchanger includes at least one opening through which the air mover moves air.

[c34] 34. The computer system of claim 33 wherein the air mover is positioned toward an upper portion of the chassis and configured to draw air upward through the chassis and past the first computer module compartment, the heat exchanger, and the second computer module compartment.

[c35] 35. The computer system of claim 33 wherein the air mover is positioned toward a bottom portion of the chassis and configured to drive air through the chassis and past the first computer module compartment, the heat exchanger, and the second computer module compartment.

[c36] 36. The computer system of claim 33 wherein the air mover is carried by the chassis.

[c37] 37. The computer system of claim 33 wherein the heat exchanger is a first heat exchanger, and wherein the computer system further comprises:

- a third computer module compartment positioned in the air flow path in the chassis and spaced apart from the second computer module compartment;
- a third plurality of computer modules held in the third computer module compartment at least partially in the air flow path; and
- a second heat exchanger positioned in the air flow path in the chassis, wherein the second heat exchanger is positioned at least partially downstream of the second computer module compartment and at least partially upstream of the third computer module compartment, and wherein the heat exchanger includes at least one opening through which the air mover moves air.

[c38] 38. The computer system of claim 33 wherein the air mover, the first computer module compartment, the second computer module compartment, and the heat exchanger are arranged vertically with respect to the chassis.

[c39] 39. The computer system of claim 33 wherein the first computer module compartment is configured to hold the first plurality of computer modules in edgewise orientation with respect to the air flow path toward a first side of the heat exchanger, and wherein the second computer module compartment is configured to hold the second plurality of computer modules in an edgewise orientation with respect to the air flow path toward a second side of the heat exchanger opposite to the first side of the heat exchanger.

[c40] 40. The computer system of claim 33 wherein each of the first plurality of computer modules is individually carried by the first computer module compartment, wherein each of the first plurality of computer modules includes at least a first computer processor, wherein each of the second plurality of computer modules is individually carried by the second computer module compartment, and

wherein each of the second plurality of computer modules includes at least a second computer processor.

[c41] 41. The computer system of claim 33 wherein the heat exchanger includes at least one internal fluid passage configured to carry a working fluid.

[c42] 42. The computer system of claim 33 wherein the heat exchanger includes at least one internal fluid passage configured to carry a working fluid having a boiling point in the heat exchanger between about 45°F and about 75°F.

[c43] 43. The computer system of claim 33 wherein each computer module of the first and second pluralities of computer modules includes at least one processor.

[c44] 44. A method for cooling first and second computer modules positioned in a chassis, the method comprising:
moving a portion of air past the first computer module in the chassis to transfer heat from the first computer module to the portion of air;
after moving the portion of air past the first computer module, moving the portion of air past a heat exchanger in the chassis to transfer heat from the portion of air to the heat exchanger; and
after moving the portion of air past the heat exchanger, moving the portion of air past the second computer module in the chassis to transfer heat from the second computer module to the portion of air.

[c45] 45. The method of claim 44 wherein the heat exchanger is a first heat exchanger, and further comprising:
after moving the portion of air past the second computer module, moving the portion of air past a second heat exchanger in the chassis to transfer heat from the portion of air to the second heat exchanger;
and

after moving the portion of air past the second heat exchanger, moving the portion of air past a third computer module in the chassis to transfer heat from the third computer module to the portion of air.

[c46] 46. The method of claim 44 wherein moving a portion of air past the first computer module includes moving a portion of air past a first plurality of computer modules arranged in parallel in the chassis, and wherein moving the portion of air past the second computer module includes moving the portion of air past a second plurality of computer modules arranged in parallel in the chassis.

[c47] 47. The method of claim 44 wherein moving the portion of air past a heat exchanger includes moving the portion of air through an opening in the heat exchanger.

[c48] 48. The method of claim 44, further comprising moving a working fluid through an internal passage in the heat exchanger, wherein moving the portion of air past the heat exchanger includes transferring heat to the working fluid.

[c49] 49. The method of claim 44, further comprising moving a working fluid through an internal passage in the heat exchanger, wherein moving the portion of air past the heat exchanger includes transferring heat to the working fluid to boil at least a portion of the working fluid in the internal passage.

[c50] 50. The method of claim 44, further comprising moving a working fluid having a boiling point between about 45°F and about 75°F through an internal passage in the heat exchanger, wherein moving the portion of air past the heat exchanger includes transferring heat to the working fluid.

- [c51] 51. A method for dissipating heat generated by a computer module in a chassis, the method comprising:
- moving a portion of air past the computer module in the chassis to transfer heat from the computer module to the portion of air;
 - moving a working fluid through an internal passage of a heat exchanger positioned in the chassis; and
 - moving the portion of air past the heat exchanger to transfer heat from the portion of air to the heat exchanger and boil at least a portion of the working fluid in the internal passage.
- [c52] 52. The method of claim 51 wherein moving a working fluid through an internal passage of a heat exchanger includes moving a working fluid having a boiling point between about 45°F and about 75°F.
- [c53] 53. The method of claim 51 wherein moving a working fluid through an internal passage of a heat exchanger includes moving a working fluid having a boiling point between about 50°F and about 65°F.
- [c54] 54. The method of claim 51 wherein the computer module is a first computer module, and wherein the method further comprises, after moving the portion of air past the heat exchanger, moving the portion of air past a second computer module in the chassis to transfer heat from the second computer module to the portion of air.
- [c55] 55. The method of claim 51 wherein the computer module is a first computer module, the working fluid is a first working fluid, and the heat exchanger is a first heat exchanger having a first internal passage, and wherein the method further comprises:
- after moving the portion of air past the first heat exchanger, moving the portion of air past a second computer module in the chassis to transfer heat from the second computer module to the portion of air;

moving a second working fluid through a second internal passage of a second heat exchanger positioned at least proximate to the second computer module in the chassis; and
moving the portion of air past the second heat exchanger to transfer heat from the portion of air to the second heat exchanger and boil at least a portion of the second working fluid in the second internal passage.

[c56] 56. The method of claim 55 wherein moving the first working fluid through the first internal passage includes moving a first portion of a refrigerant received from a refrigerant source, and wherein moving a second working fluid through a second internal passage includes moving a second portion of the refrigerant received from the refrigerant source.

[c57] 57. A method for dissipating heat generated by a computer module in a chassis, the method comprising:
moving a portion of air past the computer module in the chassis to transfer heat from the computer module to the portion of air;
moving a working fluid through an internal passage of a heat exchanger positioned in the chassis;
moving the portion of air past the heat exchanger to transfer heat from the portion of air to the working fluid; and
controlling the working fluid to maintain the working fluid at least proximate to the phase transition state while flowing through the internal passage.

[c58] 58. The method of claim 57 wherein moving a working fluid through an internal passage of a heat exchanger includes moving a working fluid having a boiling point between about 45°F and about 75°F.

[c59] 59. The method of claim 57 wherein moving a working fluid through an internal passage of a heat exchanger includes moving a working fluid having a boiling point between about 50°F and about 65°F.

[c60] 60. The method of claim 57 wherein the computer module is a first computer module, and wherein the method further comprises, after moving the portion of air past the heat exchanger, moving the portion of air past a second computer module in the chassis to transfer heat from the second computer module to the portion of air.

[c61] 61. The method of claim 57 wherein controlling the working fluid to maintain the working fluid at least proximate to the phase transition state includes controlling the pressure of the working fluid.

[c62] 62. A system for cooling first and second computer modules positioned in a chassis, the system comprising:

means for moving a portion of air past the first computer module in the chassis to transfer heat from the first computer module to the portion of air;

means for moving the portion of air past a heat exchanger in the chassis after moving the portion of air past the first computer module; and

means for moving the portion of air past the second computer module in the chassis after moving the portion of air past the heat exchanger.

[c63] 63. The system of claim 62 wherein the heat exchanger is a first heat exchanger, and further comprising:

means for moving the portion of air past a second heat exchanger in the chassis after moving the portion of air past the second computer module; and

means for moving the portion of air past a third computer module in the chassis after moving the portion of air past the second heat exchanger.

[c64] 64. The system of claim 62 wherein the means for moving the portion of air past a heat exchanger includes means for moving the portion of air through an opening in the heat exchanger.

[c65] 65. The system of claim 62, further comprising means for moving a working fluid through an internal passage in the heat exchanger.

[c66] 66. The system of claim 62, further comprising means for moving a working fluid having a boiling point between about 45°F and about 75°F through an internal passage in the heat exchanger.

[c67] 67. A computer system comprising:
means for positioning at least a first computer module in a first position along an air flow path;
means for positioning at least a second computer module in a second position along the air flow path;
means for moving a portion of air along the air flow path; and
means for removing heat from the portion of air, wherein the means for removing heat are positioned at least partially between the first computer module and the second computer module along the air flow path.

[c68] 68. The computer system of claim 67 wherein the means for positioning at least a first computer module includes means for positioning a first plurality of computer modules at least proximate to the air flow path, and wherein the means for positioning at least a second computer module includes means for positioning a second plurality of computer modules at least proximate to the air flow path.

[c69] 69. The computer system of claim 67 wherein the means for removing heat from the portion of air includes means for moving a working fluid through a passage positioned at least proximate to the air flow path.

[c70] 70. The computer system of claim 67 wherein the means for removing heat from the portion of air includes means for boiling a working fluid moving through a passage positioned at least proximate to the air flow path.

[c71] 71. The computer system of claim 67 wherein the means for removing heat from the portion of air includes means for moving a working fluid through a passage positioned at least proximate to the air flow path, wherein a first portion of the working fluid is in a liquid state and a second portion of the working fluid is in a gaseous state.